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INTEGRATION OF RENEWABLE RESOURCES INTO THE ELECTRICITY ENERGY MATRIX PRACTICAL CASE APPLIED TO A SMALL RURAL MUNICIPALITY

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1. Introduction

The transition to renewable energy sources to mitigate climate change and reduce dependence on fossil fuels is increasing [1]. Energy communities in Europe are growing in number, along with their benefits in terms of energy efficiency, cost reduction, and innovation promotion [2]. However, to achieve real renewable energy consumption, it is necessary to design and manage an energy matrix that can cover all demand. This work proposes the design and management of renewable resources to achieve energy self-sufficiency in a small rural municipality in Spain, and to establish the foundations for a sustainable energy matrix that can be replicated in other regions.

2. Case study – The municipality of Aras de los Olmos

Aras de los Olmos is a small municipality in the northwest of the province of Valencia, Spain (Fig. 1). The municipality has ideal characteristics for the implementation of renewable energy plants:

- It is located at the end of the power line.
- There is free land available.
- A large part of the economy is livestock-based.
- Close to the municipality there is a river with a steep area.
- Aras de los Olmos takes part in the EU-funded project: Natural and Synthetic Microbial Communities for Sustainable Production of Optimised Biogas (Micro4Biogas-Ref. 1010004706) [3]. Micro4Biogas aim to improve the yield, quality, speed and robustness of biogas production using strategically bioaugmented microbial strains. These strains will be used in the biogas pilot plant that will be constructed in the municipality (Fig. 1).

Fig. 1 Aras de los Olmos biogas pilot plant location [3]

3. Energy consumption study of Aras de los Olmos

The design of renewable plants must consider the consumption of the municipality, in order to be able to satisfy the electricity demand without oversizing [4]. Fig. 2 shows the weekly energy consumption during a whole year.

Seasonality also plays a role in electricity consumption. Figure 3 shows the accumulated monthly energy consumption of the municipality. Also it is necessary to know the expected annual increase in consumption. Fig. 4 shows the annual consumption from 2019 to 2022 and the annual percentage increase in the energy consumption.

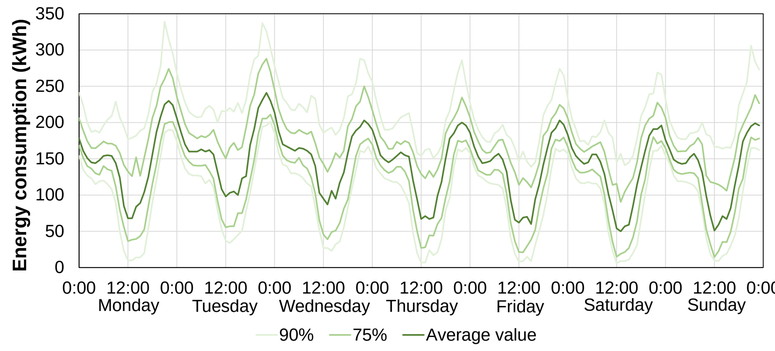

Fig. 2 Energy consumption of Aras de los Olmos

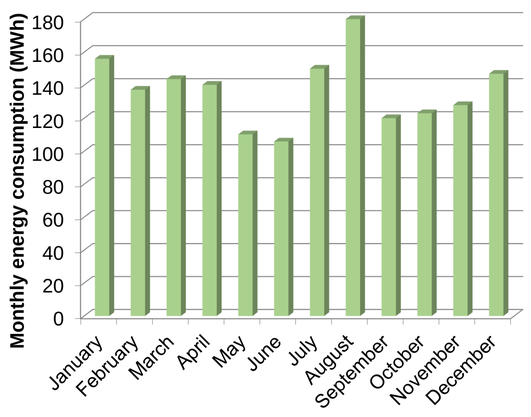

Fig. 3 Monthly energy consumption of Aras de los Olmos

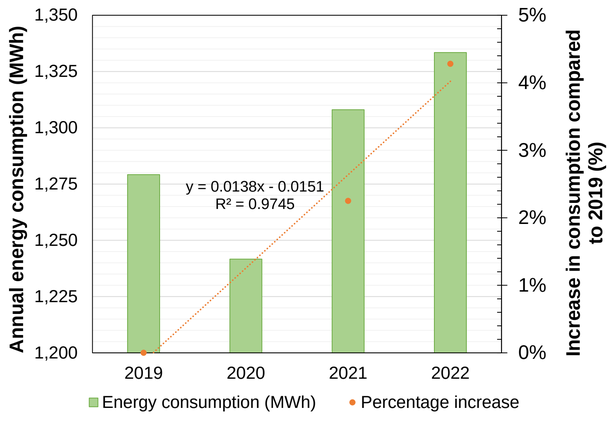

Fig. 4 Evolution of annual consumption of Aras de los Olmos

4. Energy matrix based on renewable resources and their management

Fig. 5 shows the designed energy matrix and the main characteristics of renewable energy installations designed to be able to supply the municipality for the next 30 years. In addition, the management of these sources must be considered to optimise the design [5]. A control system has therefore been designed to permanently verify the conditions to be implemented (Fig. 6).

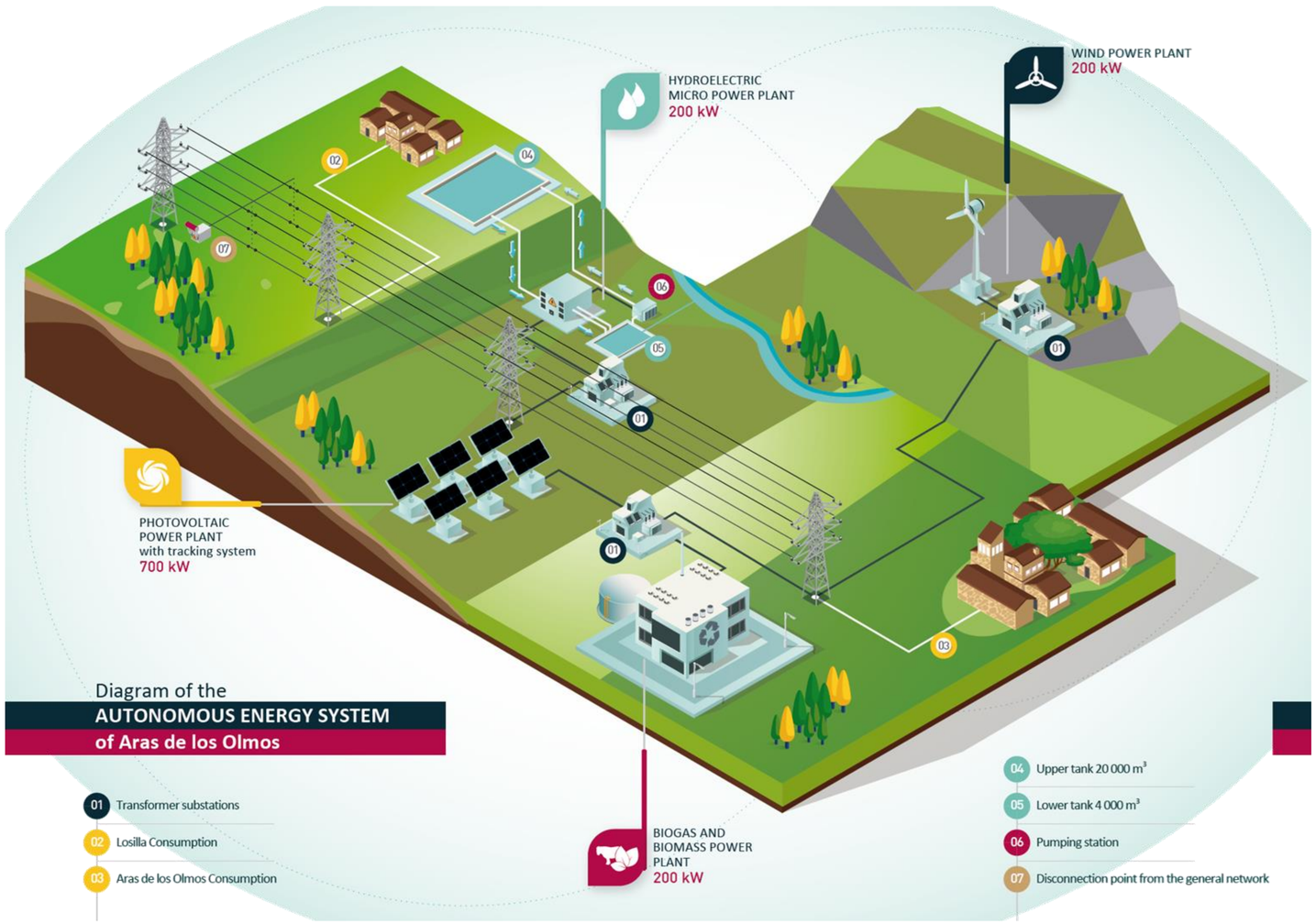

Fig. 5 Energy matrix based on renewable resources

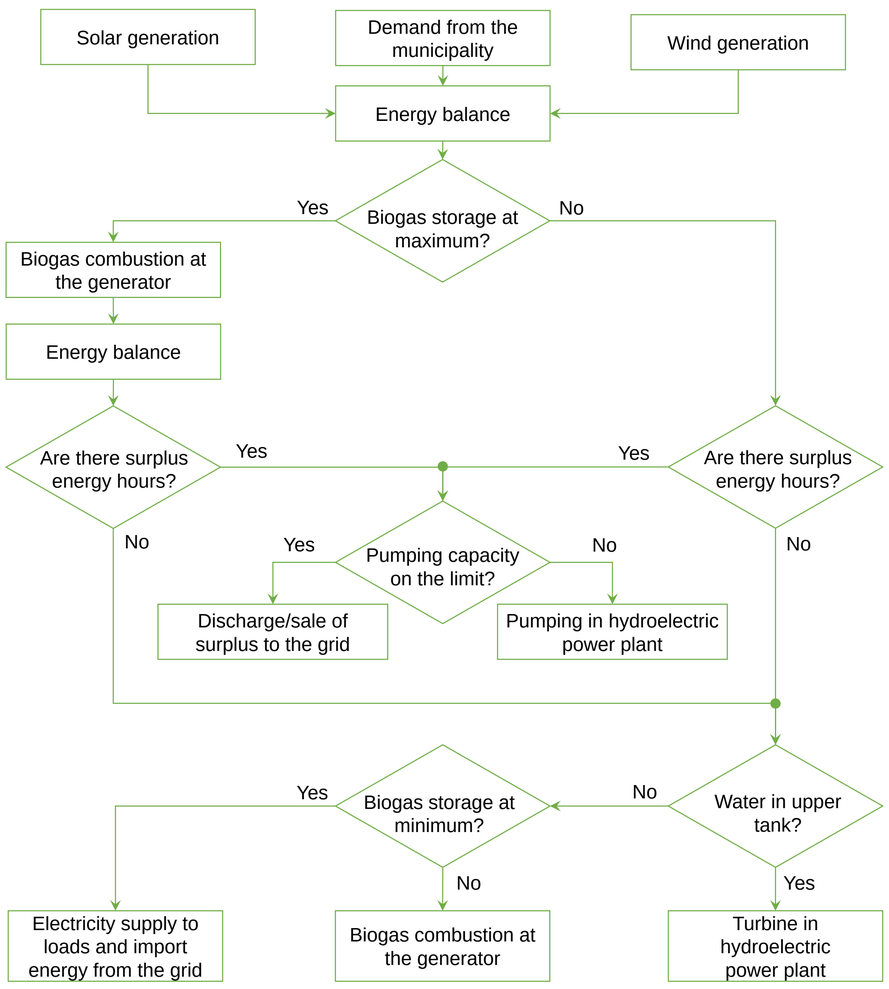

Fig. 6 Energy matrix management diagram

5. Obtained results

The energy balance shown in Fig. 7 shows that it is possible to achieve self-sufficiency with a system based exclusively on renewable resources, but not self-consumption. It is not possible to disconnect from the grid on a large scale nowadays. The energy matrix designed presents it has a series of limitations:

- Administrative procedures make it difficult and prevent it from materializing in the short term.
- It is necessary a large initial investment.
- The area must have good conditions for correct operation.
- Availability of organic matter for biogas plant depends to a large extend on the activity of the municipality.

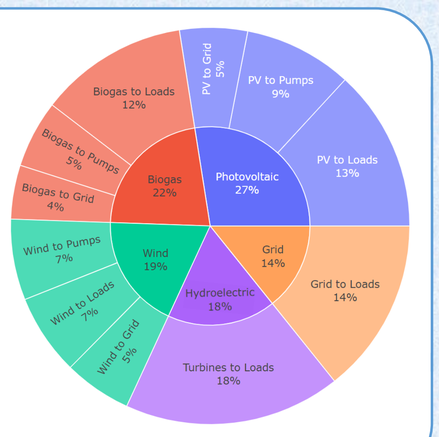

Fig. 7 Energy mix of the energy matrix

6. Conclusions

The design and management of renewable resources (PV, wind, biogas and hydroelectric) into the energy matrix has developed. The case of a rural municipality has been analysed.

The results show the possibility of achieving self-sufficiency in rural municipalities, minimising dependence on the general electricity grid. It has been noted that it is not possible to achieve full self-consumption from renewable resources on a large scale nowadays.

References: **[1]** Olabi, A. G., & Abdelkareem, M. A. (2022). Renewable energy and climate change. Renewable and Sustainable Energy Reviews, 158, 112111. **[2]** Lode, M. L., te Boveldt, G., Coosemans, T., & Camargo, L. R. (2022). A transition perspective on Energy Communities: A systematic literature review and research agenda. Renewable and Sustainable Energy Reviews, 163, 112479. **[3]** Natural and Synthetic Microbial Communities for Sustainable Production of Optimised Biogas (Micro4Biogas – Horizon 2020 Ref.: 101000470) https://micro4biogas.eu/. **[4]** Roldán-Porta, C., Roldán-Blay, C., Dasí-Crespo, D., & Escrivá-Escrivá, G. (2023). Optimising a Biogas and Photovoltaic Hybrid System for Sustainable Power Supply in Rural Areas. Applied Sciences, 13(4), 2155. **[5]** Roldán-Blay, C., Miranda, V., Carvalho, L., & Roldán-Porta, C. (2019). Optimal generation scheduling with dynamic profiles for the sustainable development of electricity grids. Sustainability, 11(24), 7111.

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